With the Author's Compts

Edgard de Cyon

MÉMOIRES

RÉDIGÉS EN L'HONNEUR DU

PROFESSEUR RAPHAËL LÉPINE

A L'OCCASION DE SA RETRAITE

PAR SES ÉLÈVES ET SES AMIS

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ON THE EFFECT OF RESISTENCE

EXERCISES AND BATHS UPON THE CIRCULATION

BY

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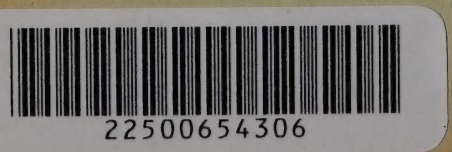

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ON THE EFFECT OF RESISTENCE EXERCISES AND BATHS UPON THE CIRCULATION

by
Sir Lauder BRUNTON Bart. M.D. LLD. ScD. FRCP.FRS.
Consulting Physician to St. Bartholomews Hospital. London.

In 1869 it was my privilege to work under the distinguished physiologist Professor Carl Ludwig, at Leipzig with whom Professor Lépine also worked shortly afterwards.

While I was in his laboratory Professor Ludwig was engaged with his pupil Dr. Sadler on a research upon the rate at which the blood flows through muscles during their contraction and relaxation. This research was afterwards continued by Ludwig along with his pupil Dr. Gaskell.

The results of these researches were that the flow of blood through voluntary muscles depends upon two things. First, the condition of the blood vessels in the muscle as regards the size of their lumen. Secondly, the amount of mechanical pressure exerted upon them by the muscular fibres during their contraction. When the muscle contracts, it squeezes into the veins all the blood contained within it, and compresses the vessels, so as to hinder the flow of blood through them. At the same time the arteries which supply the muscle dilate, and if not too much compressed from without, they allow the blood to flow more easily and quickly through them. But if they are much squeezed by the fibres of the muscle during its contraction, no blood will flow through them, notwithstanding their dilatation. If they are only slightly squeezed, the flow of blood through them may be either quicker or slower than when the muscle is not as the rate depends on the resultant of the two opposing factors viz : dilatation of the vessels themselves, and compression from without. But if the motor nerve of the muscle be

stimulated, and the muscle prevented from contracting, the flow of blood through it becomes much greater, on account of the vessels dilating and no pressure being exerted on them from without.

When the muscle is allowed to contract, it first squeezes out the blood it contains, and so a spurt of blood issues from the vein at once. When this is over the flow may be less than when the muscle is at rest or it may cease altogether. When the contraction is over, and the external pressure is thus removed, the dilated vessels allow the blood to pour through them and the maximum flow is reached. After a period of rest the vessels again contract and the rate of flow returns to the normal.

The effect which alterations in the flow of blood through the muscular system produce upon the general blood pressure is enormous, for in another research, Ludwig with his pupil Hafiz showed that when the blood vessels of the abdomen and skin are contracted, by stimulation of the vaso-motor nerves, so that blood does not flow through them, it will yet pour through the vessels of the muscles so rapidly that the general blood pressure will sink during stoppage of the heart almost as quickly as when the vaso-motor nerves are not stimulated.

This experiment shows how enormous is the effect of muscles on the blood pressure but at the same time it must not be forgotten that the vessels of the intestine and skin are also most important, so much so, that, as Ludwig has said, it is possible to bleed an animal to death into its own portal system by simply trying the portal vein and allowing the blood to accumulate in the intestinal vessels instead of returning into the general circulation.

There are thus three great vascular areas (1) the muscular (2) the intestinal (3) the cutaneous, which are in such relation to each other that as a rule, when the vessels in one area dilate, those in the others contract, and *vice versa*, so that the general blood pressure is kept approximately constant. But this constancy is only approximate, and an alteration of the vessels of any one area will affect the general blood pressure according to its extent and duration.

Another condition of much importance is temperature, for Professor Lépine has discovered that if the sciatic nerve be stimulated the blood vessels of the limb will contract if it be kept warm but will dilate if it be kept cold. This discovery, is, I think, the key to a

rational explanation of the mode of action of baths containing carbonic acid.

The mutual action and reaction of the various blood vessels in the body are thus of an exceedingly complicated character and their effect is still farther complicated by their action and reaction upon the heart.

If I were to enter upon this theme I fear I should render my paper too involved to be comprehensible and so I purpose to confine my attention chiefly to the blood vessels and only refer cursorily to the heart.

Even when we limit our survey in this manner, it is easy to understand why the results of experiments made by different observers on the effects of exercise and baths, vary so much from each other, for differences in the amount of exercise, in its duration, or the time, which elapsed between its cessation and making the observation, may lead to results of an apparently completely opposite character.

In the same way the temperature of a bath, its duration, its composition, and the condition of the body at the time, may alter its effect upon the circulation. Having been unfortunately obliged to visit Bad-Nauheim for my health I have taken the opportunity of making observations on the effect upon my pulse and blood pressure of the baths, massage, and exercises prescribed for me by Professor Schott who has done so much to introduce, and render successful, this method of treating cardiac disease. The first six baths were saline without carbonic acid, the last fifteen contained carbonic acid. The temperature of the first five was 39,5 C. and of the later was 39 C. gradually reduced to 35 C.

The effect of the baths on the rate of the pulse was practically nil the average rate being 101 before entereing the bath and 102 on leaving it. I was a good deal surprised at this result, for on a former visit to Nauheim my pulse appeared to me to be slowed by the baths.

During the whole of my present visit, and for two weeks before I came my pulse has been persistently quicker than usual, for my normal pulse has been 76 per minute, for many years, and now it is generally between 80 and a 100. This may due to a slight febrile condition because my present illness began with a severe attack of influenza and infection by a variety of streptococci, staphylococci

and bacilli and my temperature is now occasionnally 37,2 C. and occasionally 36,1 C.

There is a possibility, although not a probability that the pulse rate may be influenced by the fact that for more than 6 weeks I have been taking 30 grains of iodide of sodium daily, as my radial arteries were becoming thick, and my arterial tension which is normally 120 was rising to over 140 mm.

Though the rate of the pulse was not affected by the baths its quality was markedly affected by them. After the bath the pulse felt to the finger much fuller and softer, and this change in quality is shown by the sphygmograph (figs. 1 und 2).

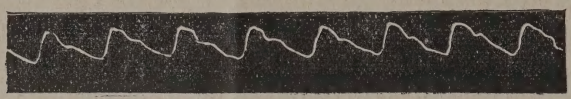

Fig. 1. — Sphygmogram before the bath.

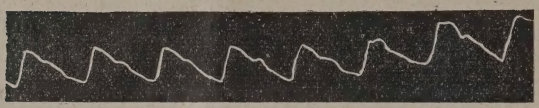

Fig. 2. — Sphygmogram after the bath.

After the bath I rested in bed rather more than an hour and than had abdominal massage consisting chiefly of deep stroking movements down the course of the aorta and iliac arteries.

The alteration produced by this procedure in pulse rate, and in blood pressure, was surprisingly small. I had rested an hour before the massage was begun and the pulse was then 96, after the massage it fell to 91. This fall of 5 beats per minute must be due to the massage as I had been resting so long before it was begun. The blood pressure remained practically unaltered, being on an average 119 mm. before, and 118 mm. after massage.

The blood pressure was estimated by Riva-Rocci's method but with an armlet 12 cm. broad connected to a Potain's sphygmomanometer which was compared from time to time with a mercurial one in order to ensure its accuracy. One point came out with almost unvarying regularity viz., that the pressure necessary to obliterate the pulse with a rising pressure was 5 mm. higher, than that at

which the pulse reappeared with a falling pressure. The observer who felt the pulse and announced its appearance and disappearance could not see the dial of the manometer and consequently the observation was free fron any error due to mental suggestion.

The pulse wave appears fuller after massage as if the heart sent a larger quantity of blood into the vessels at each beat. This is illustrated by the sphygmograms (figs. 3 und 4).

Immediately after the necessary observations had been made on the pulse and blood pressure, after massage resistence exercises were begun.

These consisted in raising the arms to a level with the shoulder

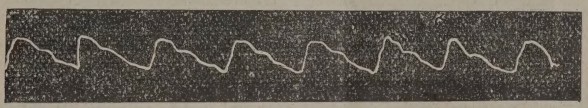

Fig. 3. — Sphygmogram before massage.

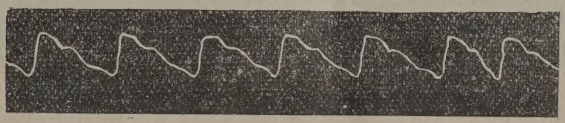

Fig. 4. — Sphygmogram after massage.

and lowering them again, in extension, flexion, adduction, and abduction of the arms and legs, and in bending, straightening and rotating the body.

These movements were done very slowly and there was an interval of one to two minutes of rest between successive movements.

The resistance opposed was very carefully graduated by the masseur (Mr. Heintzman) being very slight at the commencement of the course, and gradually increased as I gained strength. The effect of these movements on the pulse rate was very slight, the mean being 93 per minute before they were begun and 91 after they were finished. Their effect on blood pressure was small but very constant. With few exceptions it fell about 5 mm., the average being 121 mm. before and 115 mm. after the exercises.

In all the observations on blood pressure I have taken the lower reading as the pressure was falling, in order to make them all com-

parable, for although it was taken both as the pulse stopped with ascending pressure, and reappeared with descending pressure, in all my observations on the effect of massage and exercises, yet in the baths it was often taken by myself without assistance, and I found it easier to raise the pressure to 150 at once, and note the pressure at which the pulse reappeared than to raise the pressure at the same time that I felt the pulse.

The addition of 5 mm. to each number I have given will indicate accurately the pressure at which the pulse ceased to be perceptible

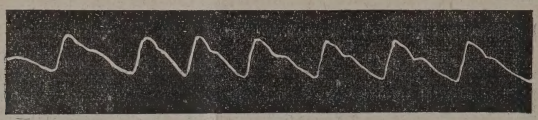

Fig. 5. — Sphygmogram before resistence exercises.

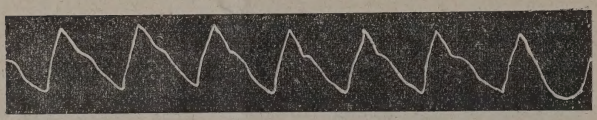

Fig. 6. — Sphygmogram after resistence exercises.

with an increasing pressure. The sphygmogram taken after exercises shows a pulse wave more ample in extent, rather more abrupt in its rise and quicker in its fall then before, These characters appear to me to indicate a more strongly acting heart with less resistence to overcome on account of dilatation of the arteries (figs. 5 und 6).

The necessity for careful graduation of the exercises is shown by an experiment I made.

The masseur put me through three movements against strong resistence and with very short intervals between them. My blood pressure at once rose from 117 mm. to 165 mm. This is exactly what we would expect from Ludwigs experiments. After a few minutes spent in taking tracings and making observations, the pressure fell to 130. The sphygmograms taken after exercises with great resistence show a quicker rate, less amplitude and quicker fall than before (figs. 7 und 8).

To resume the results of my observations. The pulse rate has been little affected either by baths, massage, or movements, but each of

these means of cure has altered its character rendering it fuller and softer.

The blood pressure has been little affected either by baths or massage but is has been almost invariably lowered 5 mm. by exercises.

The result of these methods of cure applied during five weeks has been increase of strength, greater ability for exercise, diminished dilatation of the heart, as ascertained by percussion, and restoration of blood pressure to the normal. A day or two after my arrival here

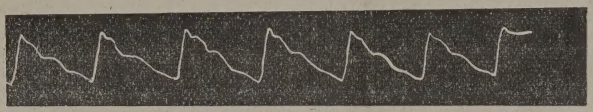

Fig. 7. — Sphygmogram before severe resistence exercices.

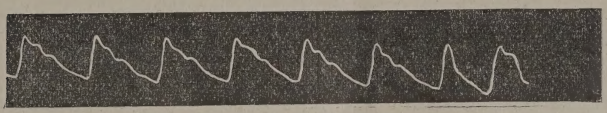

Fig. 8. — Sphygmogram after severe resistence exercices.

it was 138 (falling pressure) or 145 rising pressure, whereas it is now at the end of the course 115 or 120.

Baths, massage, and exercises have all the power to raise or lower blood pressure, according to the way in which they are applied, Differences in the results obtained by different observers are almost certainly due to differences in the mode of application and the good results I have observed to follow from a course of treatment at Bad-Nauheim both in myself, and in many of my patients, are due to careful adjustment of each means of cure to the needs of the patient.

The effects of carbonic acid baths have received a rational explanation by the experiments of Professor Lépine whom every one who has the pleasure of knowing regards not only with the utmost esteem but also with affection and to whom every one wishes long life and continued activity for the sake of science and of mankind.